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Structure of analysis-minus-observation misfits within a global ocean reanalysis system: implications for atmospheric reanalyses

James Carton and Gennady Chepurin
University of Maryland, Atmospheric and Oceanic Sci., College Park, United States (carton@atmos.umd.edu)

While atmospheric reanalyses do not ingest data from the subsurface ocean they must produce fluxes consistent with, for example, ocean storage and divergence of heat transport. Here we present a test of the consistency of two different atmospheric reanalyses with 2.5 million global ocean temperature observations during the data-rich eight year period 2007-2014. The examination is carried out by using atmospheric reanalysis variables to drive the SODA3 ocean reanalysis system, and then collecting and analyzing the temperature analysis increments (observation misfits).

For the widely used MERRA2 and ERA-Int atmospheric reanalyses the temperature analysis increments reveal inconsistencies between those atmospheric fluxes and the ocean observations in the range of 10-30 W/m2. In the interior basins excess heat during a single assimilation cycle is stored primarily locally within the mixed layer, a simplification of the heat budget that allows us to identify the source of the error as the specified net surface heat flux. Along the equator the increments are primarily confined to thermocline depths indicating the primary source of the error is dominated by heat transport divergence. The error in equatorial heat transport divergence, in turn, can be traced to errors in the strength of the equatorial trade winds. We test our conclusions by introducing modifications of the atmospheric reanalyses based on analysis of ocean temperature analysis increments and repeating the ocean reanalysis experiments using the modified surface fluxes. Comparison of the experiments reveals that the modified fluxes reduce the misfit to ocean observations as well as the differences between the different atmospheric reanalyses.